Software Downloading

the Good, the Bad and the Ugly

Presented by Tom Roth
at the 2001 FAA Software Conference

Why do we like software downloading?

- **We used to program individual devices and then plug them into a socket or solder them directly onto a board.**
- **This practice produced the weakest link in our avionics products.**
- **We now have flash memory devices which are electrically alterable and thereby we can program them in-place on the PC board.**
- **Eliminating sockets or the need to un-solder a component increases the reliability of our avionics.**

With the advent of flash memories, we in the avionics industry have much to gain from removing mechanical sockets from our designs. In addition to removing one more error opportunity of inserting the wrong programmed chip on the board has been eliminated. In order to support this new technology we need to review our media configuration control practices for our equipment.

How to handle the field and non-field situation

- **If one steps back and looks at all the media that gets loaded into an avionics product you will observe two situations.**
  - **First, some media loading can only be accomplished at the board level when the unit is first powered up.**
  - **Then other media loading is more efficiently loaded from the front panel jack.**
  - **Then one observes that the media loaded at the board level will have the least likelihood to change whereas the media loaded from the front panel has the most likelihood to change.**
  - **Also, the media loaded at the board level has a tendency to be associated with the physical layer interface of the system whereas the media loaded from the front panel has a tendency to be associated with the application layer interface.**

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If one steps back and looks at all the media that gets loaded into an avionics product you will observe two situations. First, some media loading can only be accomplished at the board level when the unit is first powered up. Then other media loading is more efficiently loaded from the front panel jack. Then one observes that the media loaded at the board level will have the least likelihood to change whereas the media loaded from the front panel has the most likelihood to change. Also, the media loaded at the board level has a tendency to be associated with the physical layer interface of the system whereas the media loaded from the front panel has a tendency to be associated with the application layer interface. Considering the conditions listed hereinbefore leads us to the conclusion that many product's media is best controlled from two independent perspectives.

These two independent perspectives of control mean that not one software part number but two software part numbers will control the product's software configuration best. The first software part number will be the configuration of the media loaded at the board level. We will call this software part number the BOOT configuration control number. The second software part number will be the configuration of media loaded at the unit level through the port in the front of the unit. We will call this software part number the APPLICATION configuration control number.

How to handle the field and non-field situation

- **These two independent perspectives of control mean that not one software part number but two software part numbers will control the product's software configuration best. (this usually means two configuration indices)**
  - **The first software part number will be the configuration of the media loaded at the board level. We will call this software part number the BOOT configuration control number. (This typically is not field-loadable software)**
  - **The second software part number will be the configuration of media loaded at the unit level through the port in the front of the unit. We will call this software part number the APPLICATION configuration control number. (This typically is field-loadable software)**

Boot Software Part Number includes:

- **Processor #1 boot software image**
- **Processor #2 boot software image**
- **EPLD image**
- **JTAG programmer to be used for programming processor # 1 boot software**
- **User's Guide for Jtag%%.exe**
- **BDM programmer to be used for programming processor # 2 boot software**
- **Parameter file used by Prog16.exe to facilitate software programming**
- **User's Guide for Prog16.exe**
- **Altera EPLD JAM Programmer to be used for programming the EPLDs.**
- **The remainder of these files permit the outsource board manufacture to perform test vectors on the programmed part to verify that the EPLD was programmed correctly and operates as expected in the circuit.**

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It is obvious from this long list of data required to prepare the Unit to allow the BOOT software to be programmable from the JTAG or BDM port that to attempt to control this process by the distribution of individual media of each of the above items would be an accident waiting to happen. Hence the decision was made to distribute all of these media simultaneously. We will do this by placing all of these media on one CD called the Unit BOOT Configuration CD. There are some special considerations to be considered when distributing media on CD. One of them is the fact that many tools need to execute from writable media since their execution assumes the ability to write data back to the installing program. Hence it was necessary to include some special notes in a README.TXT file on the CD. Examples of those notes are as follows:

1. Jtag%%.exe will not run from the CD media. Please copy it and the associated hex file (Bootrom.hex) to a local writable drive before running.

2. The epld files must also be copied to a local writable drive before they are used and the read-only attribute should be removed from all of them except for the ".jbc" file.

3. The asap2.exe (Altera EPLD JAM Programmer) is a self-extracting installation file. Please use the online help for usage instructions.

Application Software Part Number includes:

- **Microprocessor # 1 application software image**
- **Microprocessor #2 application software image**
- **Microprocessor #2 input/output device driver image**
- **Unit Software Loader**
- **DOS-based Unit Software Loader**
- **Database Loader**
- **Other files in this directory are support files for this application**
- **Database Loader Installation program**

It is obvious from this long list of data required to put the APPLICATION software into the unit via the RS-232 port that to attempt to control this process by the distribution of individual media of each of the above items would be an accident waiting to happen, also Hence the decision was made to distribute all of these media simultaneously. We will do this by placing all of these media on one CD called the Unit APPLICATION Configuration CD. There are some special consideration to be consider when distributing media on CD. These special considerations are made by including a README.TXT file at the root level on the CD.

Unit Software Configuration Identification

- **The unit will be marked as follows to indicate a reference to where to find the Application Software part number and the actual Boot Software part number:**

SEE AUX %% PAGE FOR

APPLICATION SOFTWARE MOD STATUS.

BOOT SOFTWARE MOD [____]

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This now leads us to the Unit Software Configuration identification. The fact that there are two software configurations involved in the dispatch of this unit needs to be communicated to the appropriate people. We will accomplish this by noting on the unit itself that two configurations apply. The unit will have a label which reads as follows:

SEE AUX %% PAGE FOR
APPLICATION SOFTWARE MOD STATUS.
BOOT SOFTWARE MOD [____]

Therefore the Unit Boot Software number will appear on the last line of the above label. The Unit Application Software Mod Status is only visible by observing the AUX %% page referenced on the label above, while the Boot software mod status will be listed on this label on the top of the unit.

Application Software Identification markings

- **Notice 8110.77 entitled "Guidelines for the Approval of Field-Loadable Software" provides us with guidance for approving field-loadable software (FLS).**
- **This guidance implies that the Unit Application Software Configuration status needs to be written somewhere in the airplane. We have, in this example, elected to place this marking in the Aircraft Log Book.**

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Notice 8110.77 titled "Guidelines for the Approval of Field-Loadable Software" provides us with guidance for approving field-loadable software (FLS). Section 9 of this guidance document is included hereinafter since it specifically addresses the maintenance and part marking considerations as they apply to FLS. Paragraphs 9b, 9e and 9f provide the specific guidance we are using that applies to this product.

9. MAINTENANCE AND PART MARKING CONSIDERATIONS. Maintenance and part marking for FLS should be performed in accordance with the appropriate part of 14 CFR. Additional maintenance and part marking considerations that apply specifically to FLS using TC, ATC, STC, or TSO, process are discussed below:

> b. The applicant's AMM or IFCA should include a procedure that requires maintenance personnel to verify the software part number configuration before and after maintenance is performed on the airborne equipment.
>
> e. For airborne equipment having only one part number, which represents a specific configuration of software and hardware, the unit identification on the nameplate should be changed when the new software is loaded. When new software is loaded, the software part number stored in the target computer after data loading should be verified electronically. It should be verified that the electronic software part number and the unit part number displayed on the nameplate are an approved configuration prior to returning the unit to service.
>
> f. Changes to software part number, version, and/or operational characteristics should be reflected in the Operator's Manual, Aircraft Flight Manual, Aircraft Flight Manual Supplement, and/or any other appropriate document.

This guidance would then imply that the Unit Application Software Configuration status needs to be written somewhere in the airplane. We have, in this example, elected to place this marking in the Aircraft Log Book.

Application software marking needs to address:

- **The specific marking requirements for the application software SW MOD marking in the airplane installation**
- **The specific documents which need to address the application software SW MOD marking methods and practices**
- **How internal company personnel will need to identify the application software SW MOD level**
- **How Software Service Bulletins will need to specify the application software SW MOD marking**

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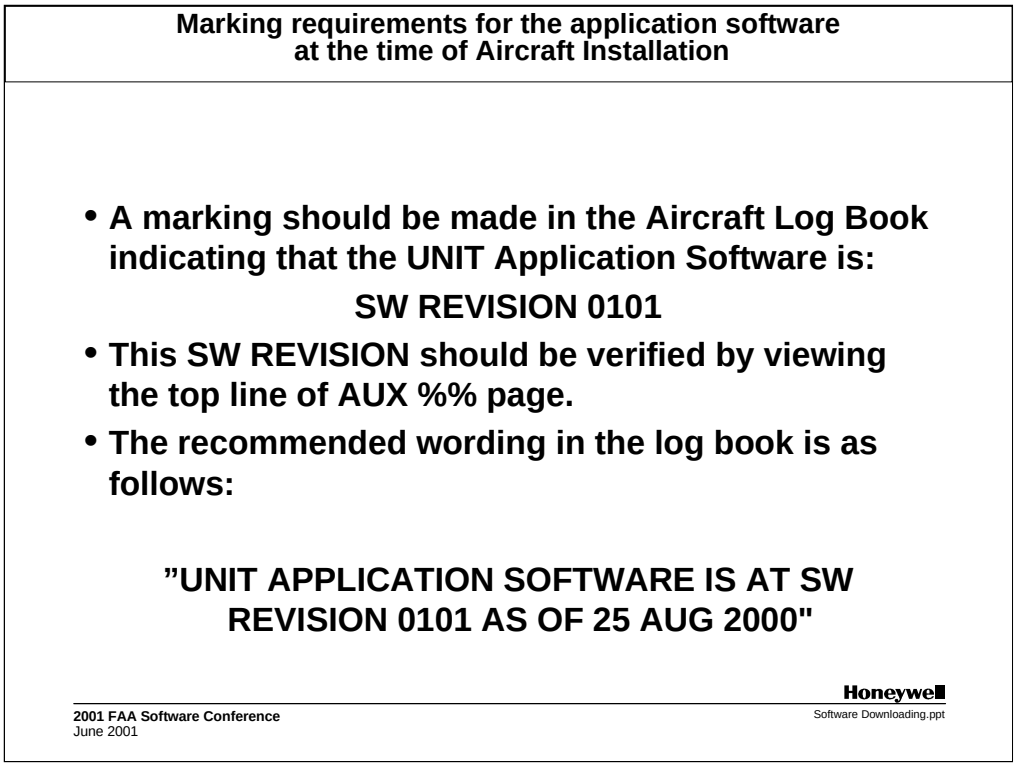
The following specific requirements, which will be addressed here, are the following:

- The specific marking requirements for the application software SW MOD marking in the airplane installation
- The specific documents which need to address the application software SW MOD marking methods and practices
- How internal company personnel will need to identify the application software SW MOD level
- How Software Service Bulletins will need to specify the application software SW MOD marking

In this section a Software Revision of 0101 is used as an example. This 0101 must be modified to agree with the Unit Application Mod Status which in this case is the last 4 digits of the Application Software part number in force. Also the current date field uses "25 AUG 2000" as the typical current date. The date used should be the date the new software is installed in the specific unit.



Marking requirements for the application software at Aircraft Installation

A marking should be made in the Aircraft Log Book indicating that the UNIT Application Software is:

SW REVISION 0101

This SW REVISION should be verified by viewing the top line of AUX %% page.

The recommended wording in the log book is as follows:

”UNIT APPLICATION SOFTWARE IS AT SW REVISION 0101 AS OF 25 AUG 2000"

What Manuals need updating ? (1 of 3)

- **<u>UNIT STC Manual</u> - Needs to specify how the installation of this unit is documented.**

- **<u>UNIT Installation Manual</u> - The Installation Manual needs to make the installer aware of the need to make a log book entry in the Aircraft Log Book upon installation of the UNIT. It may also be appropriate to inform the installation personnel of the basic UNIT software configuration control process.**

<u>UNIT STC Manual</u>

The UNIT STC manual needs Section 5 - "Documenting Installation" modified to state:

> "A marking should be made in the Aircraft Log Book indicating that the UNIT Application Software is:
>
> SW REVISION 0101
>
> This SW REVISION should be verified by viewing the top line of AUX %% page.
>
> The recommended wording in the log book is as follows:
>
> UNIT APPLICATION SOFTWARE IS AT SW REVISION 0101 ON 25 AUG 2000"

<u>UNIT Installation Manual</u>

The UNIT Installation Manual needs to make the installer aware of the need to make a log book entry in the Aircraft Log Book upon installation of the UNIT. An appropriate set of words may be as just above

It may also be appropriate to inform the installation personnel of the basic UNIT software configuration control process. The following words may be appropriate to suit this cause:

> "The UNIT Boot software configuration marking will be on the unit on the last line of the Auxiliary Label and the UNIT Application software configuration indication will be on the UNIT display screen's AUX %% PAGE where the first line of that display reads:
>
> SW REVISION 0101
>
> where the 0101 is the last four digits of the UNIT Application Software part number. Note that it will not be possible to display the Boot software configuration number on the product's display."

What Manuals need updating ? (2 of 3)

- **<u>UNIT Maintenance Manual</u> - The UNIT Maintenance Manual needs to make the maintenance personnel aware of the methods used to indicate and mark the software configuration of the UNIT. It may also be appropriate to inform the maintenance personnel of the basic UNIT software configuration control process.**

<u>UNIT Maintenance Manual</u>

The UNIT Maintenance Manual needs to make the maintenance personnel aware of the methods used to indicate and mark the software configuration of the UNIT. An appropriate set of words may be as follows:

> "A marking should be made in the Aircraft Log Book indicating that the UNIT Application Software is:
>
> SW REVISION 0101
>
> This SW REVISION should be verified by viewing the top line of AUX %% page.
>
> The recommended wording in the log book is as follows:
>
> UNIT APPLICATION SOFTWARE IS AT SW REVISION 0101 ON 25 AUG 2000"

It may also be appropriate to inform the maintenance personnel of the basic UNIT software configuration control process. The following words may be appropriate to suit this cause:

> "The UNIT Boot software configuration marking will be on the unit on the last line of the Auxiliary Label and the UNIT Application software configuration indication will be on the UNIT display screen's AUX %% PAGE where the first line of that display reads:
>
> SW REVISION 0101
>
> where the 0101 is the last four digits of the UNIT Application Software part number. Note that it will not be possible to display the Boot software configuration number on the product's display."

What Manuals need updating ? (3 of 3)

- **<u>UNIT Pilot's Guide</u> - The UNIT Pilot's Guide should inform the pilot of how to observe the software configuration of his unit.**

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<u>UNIT Pilot's Guide</u>

The UNIT Pilot's Guide should inform the pilot of how to observe the software configuration of his unit.

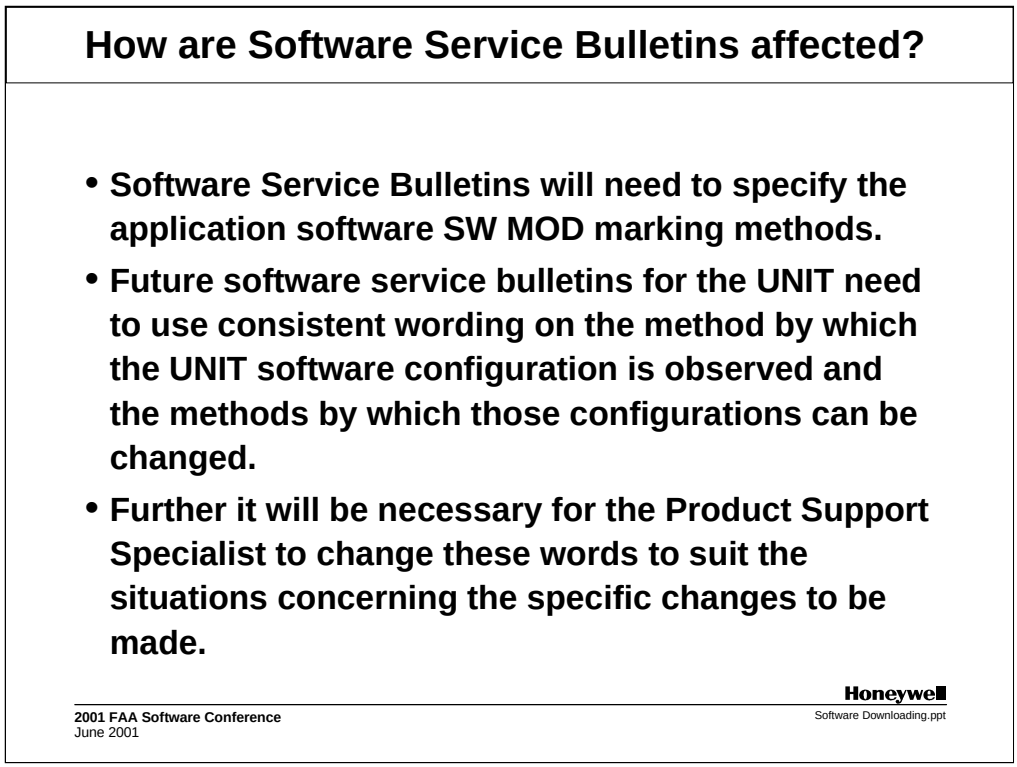
> "The UNIT Boot software configuration marking will be on the unit on the last line of the Auxiliary Label and the UNIT Application software configuration indication will be on the UNIT display screen's AUX %% PAGE where the first line of that display reads:
>
> SW REVISION 0101
>
> where the 0101 is the last four digits of the UNIT Application Software part number. Note that it will not be possible to display the Boot software configuration number on the product's display. A marking should be in the Aircraft Log Book indicating the configuration of the UNIT Application Software. That note would typically read as follows:
>
> > UNIT APPLICATION SOFTWARE IS AT SW REVISION 0101 ON 25 AUG 2000"

Factory Identification of the application software SW MOD level

- **The only means by which factory inspectors can identify the UNIT Application Software part number is by viewing the first line of AUX %% page which would typically read as follows:**

SW REVISION 0101

where the 0101 is the last four digits of the UNIT Application Software part number.



How Software Service Bulletins will need to specify the application software SW MOD marking.

Future software service bulletins for the UNIT need to use consistent wording on the method by which the UNIT software configuration is observed and the methods by which those configurations can be changed. A set of words that may be used to serve this cause is as follows:

"The UNIT Boot software configuration marking will be on the unit on the last line of the Auxiliary Label and the UNIT Application software configuration indication will be on the UNIT display screen's AUX %% PAGE where the first line of that display reads:

SW REVISION 0101

where the 0101 is the last four digits of the UNIT Application Software part number. Note that it will not be possible to display the Boot software configuration number on the product's display. A marking should be in the Aircraft Log Book indicating the configuration of the UNIT Application Software. That note would typically read as follows:

UNIT APPLICATION SOFTWARE IS AT SW REVISION 0101 ON 25 AUG 2000”

Further it will be necessary for the Product Support Specialist to change these words to suit the situations concerning the specific changes to be made.

Another example of software loading (1 of 5)

- A System consists of three pieces:
  - A base unit which accepts expansion cards
  - Expansion cards themselves
  - A datacard which plugs into the front of the unit and stays in that position when airborne.
- Each of these pieces has its own configuration index and software part number.
- The software in each of the pieces is somewhat independent of the software in the other pieces, from an OSI functional layer model concept.

Another example of software loading (2 of 5)

The Base Unit

- **The base unit contains non-field loadable software to support its main function and a keyboard and display function.**
- **The base unit also has one more microprocessor function which is field-loadable and that microprocessor, therefore has a boot which is not field-loadable.**
- **This base unit has its software part number on a label on the unit near its serial tag in a normal fashion.**

Another example of software loading (3 of 5)

The Expansion Board

- **The expansion boards only contain boot software which is not field-loadable.**
- **When an expansion board is added to the unit, a tag is placed on the outside of the base unit indicating the presence of the expansion board and also indicating the software part number of the boot software contained therein.**

Another example of software loading (4 of 5)

The Data Card

- **The data card, with its own software part number printed on the data card, contains the following items:**
  - **Database information necessary for the operation of the unit.**
  - **The software image which loads into the base unit to control its functions.**
  - **The software images for each of the expansion boards, to control their function.**

Another example of software loading (5 of 5)

- **Therefore the database distribution will always contain and control all application software necessary in the System.**
- **When a new expansion board is released, the new application images are added to the data card.**
- **The data card is marked to indicate the new software part number.**
- **Each new application software added to the datacard requires a new certification, however distribution to the field is automatic with the database distribution. A Software Service bulletin only required in the event of a AD.**

We do not want this to happen!